NCVER

Thinking beyond numbers: Learning numeracy for the future workplace

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An Adult **Literacy** National **Project** Report

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Publisher's note

Additional information relating to this research is available in *Thinking beyond numbers: Learning numeracy for the future workplace—Support document*. It can be accessed from NCVER's website <http://www.ncver.edu.au/publications/1795.html>.

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Foreword

Nobody debates the need for numeracy skills. Indeed, their importance is recognised by the Australian Government through the incorporation of numeracy skills in the key objectives of Australia's current vocational education and training (VET) strategy. National and international research shows that adults with low numeracy skills are not only disadvantaged economically, but are less likely to participate in training and development activities. The research has also shown that participation in numeracy training can change this. However, what is not well understood is how numeracy skills are best learned in workplaces. Given the importance of adhering to occupational health, safety and welfare regulations and the increasing use of new technologies, having appropriate numeracy skills is paramount in the workplace.

This study sought to address the issue of numeracy training in the workplace and was funded under the Department of Education, Science and Training's Adult Literacy and Numeracy Research Program—a national research program managed by the National Centre for Vocational Education Research (NCVER).

A fundamental issue in numeracy training is how the term 'numeracy' is conceptualised. There is very often discord between how numeracy and numeracy skills are viewed by those 'on the floor' and by management. The report highlights the way in which employees and employers define numeracy in a workplace context and how this may influence their perceptions of their own or their workers' numerical ability. The report also focuses on the past numeracy experiences of workers and how these may influence the type of training preferred.

The report proposes a number of strategies that could aid the learning and transference of numeracy skills in the workplace. As such, the report will be of interest to educators, workplace trainers, as well as employers.

Tom Karmel
Managing Director, NCVER

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Key messages

Through interviews with a range of stakeholders and workers in manufacturing and aged care, this study examined the use, learning and transference of workplace numeracy skills, as well as current understandings of the term 'numeracy'. The study challenges the training system, training organisations, and trainers to provide numeracy training that makes links directly to workplace contexts.

- Numeracy skills are vital in the workplace context and will become more so because of the increasing use of technology.
- Many workers tacitly and competently exercise numeracy skills in the workplace, despite lacking confidence in their abilities, which is often associated with negative experiences of secondary school mathematics.
- Numeracy skills can be extended by being framed within other workplace training, pitching them at an appropriate and attainable level and having practical application for the worker, and ideally be designed and delivered by a training team which has both adult numeracy expertise and local enterprise and industry knowledge.

Executive summary

Background and research purpose

Globalisation and technological advances are rapidly increasing workplace numeracy demands. With greater numbers of workers currently engaged in more sophisticated maths-related tasks, numeracy is now recognised by the Australian Government, industry and employer groups as an essential employability skill. In Australia, numeracy is also recognised as an equity issue, as adults with poor numeracy skills are more likely to be unemployed or have relatively low work positions with fewer promotion prospects and lower wages.

Although the term 'numeracy'—originally coined as the mathematical equivalent to 'literacy'—is used in policy and education circles, it has yet to gain popular usage or understanding in the wider community or industry. At policy and research levels, numeracy is understood to encompass the confident and thoughtful application of a broad range of mathematical skills to real-world purposes at home, in the workplace or in the community. It also includes the ability to interpret, analyse and communicate mathematically related information.

Workplace numeracy research suggests that numeracy for the workplace incorporates: the skills of measurement; number calculations; reading and interpreting diagrams; and using simple formulae. It also includes collection, analysis and interpretation of data. In addition, a 'readiness for thought and action' (the capacity to appreciate the purpose of numeracy-related tasks and to use numeracy skills for critical thinking, analysing situations and solving problems) has been identified as important in workplaces. This capacity relates to a personal confidence to use mathematics in appropriate situations.

Research into workplace numeracy has also identified a phenomenon described as the 'invisibility of numeracy' at work, meaning that numeracy is often used in a *tacit* or *unconscious* way, embedded within other tasks, although not acknowledged as numeracy.

Currently little is known about learning and transference of workplace numeracy skills, nor the understandings of the term 'numeracy' held by people with influence in industry, business and training. This report documents a study which sought to address these gaps with a view to identifying useful models for future numeracy skills acquisition, transfer and development.

Methodology

The study was guided by themes derived from critical analysis of Australian and international research into workplace numeracy and literacy. It used semi-structured interviews with a variety of industry representatives (key stakeholders), as well as case studies of three worksites. These case study worksites were selected to represent a range of industries with different profiles in terms of employees, technology use and training cultures and included an aged care facility with a predominantly female workforce over 40 years of age; a 'high tech' engineering manufacturer of parts for the automotive industry, with a large, predominantly male workforce; and a small, traditional, family-owned sheetmetal engineering factory in which technology is increasingly being used. The case studies included work shadowing and interviews with workers, supervisors and managers to explore the numeracy skills used at the worksite; workers' attitudes to numeracy and

school mathematics; learning and transfer of workplace numeracy skills; and workers' engagement with the meaning and consequences of numeracy-related tasks.

Key stakeholders and workplace managers were asked about their conceptions of numeracy, as well as their opinions on the importance of numeracy skills for the workforce, including trends that may have an impact on the current situation; the relationship between workplace numeracy and school mathematics; and effective strategies for future numeracy skills development.

Findings and implications for numeracy skills development

The study found that workers taking responsibility for their own work areas use a wide range of numeracy skills, which are often embedded and unrecognised within routine workplace tasks. In the manufacturing and aged care workplaces studied, the numeracy skills of measurement, number calculations, reading and interpreting diagrams and using simple formulae are commonly used. Interestingly, metric measurement and digital readouts have made fraction manipulation far less necessary, and division without a calculator was seldom used. A trend towards workers taking greater responsibilities within their own specialised situations is likely to necessitate even more independent use of their numeracy skills than in the past. There are also increasing expectations that workers engage in collection, display, analysis and interpretation of data—not only related to efficiency, product quality, or patient care but also to matters of occupational health and safety (OH&S). It is apparent that taking on positions of greater responsibility in the workforce will require confident use of these numeracy skills and an accompanying facility with the relevant computer software.

Unlike school mathematics practices, workplace numeracy tasks are performed using idiosyncratic methods developed within the workplace and couched in task-specific language particular to the industry or workplace. They are also performed with differing degrees of accuracy, as appropriate to the task and its consequences, with 'in the head' calculation strategies and estimation of measurements a common feature, especially when making judgements on the adequacy of material stocks, productions rates or occupational health and safety decisions about lifting and storage. Although the numeracy skills are adapted to specific strategies for each industry, they tend to be based on an underpinning of skills developed through a range of prior learning experiences and, in many cases, transferred between workplaces and life situations.

It was also apparent from the interviews that workplaces want workers who appreciate the 'big picture' surrounding their work and who use their numeracy skills proactively to improve work practices. To some extent, all of the workers interviewed used individual judgement and problem-solving beyond mere repetitive or procedural use of mathematical skills within their jobs. They all showed awareness of the consequences of the numeracy-related tasks they undertook and took responsibility for their performance to the required degree of accuracy.

These observations are in accord with broad conceptions of numeracy which emphasise the confident use of judgement on the appropriate use of a range of mathematical skills. Acquiring these numeracy skills is important for all new and existing workers. However, interviews with workplace managers and key stakeholders also indicated that the single term 'numeracy' tends to convey a narrow picture of basic number calculations rather than the broader policy and research conceptualisations.

It is clear that, in order for numeracy to receive the necessary attention in the training agenda, it must first be extracted from within the acronym 'LLN' (language, literacy and numeracy) at the policy level. In addition, in order to uncover the true training needs in each industry, the scope and breadth of numeracy needs more explicit unpacking within the workplace context as it gets further from policy to practical implementation, particularly in industry training packages.

Workplace numeracy learning and training

Most workers displayed signs of anxiety when discussing secondary school mathematics education, which they saw as useless, abstract, and taught without relevance. Commonly their mathematics learning experiences have resulted in a negative self-image with respect to numeracy and a consequent lack of recognition of their existing ability. This was despite competence in the fundamental arithmetic skills of addition, subtraction and multiplication. Even when they had learned new numeracy skills in the workplace, such as complex tallying strategies and calculating freight costs, there was a tendency for the less confident to regard them as merely part of the job or 'common sense', perhaps because they no longer resembled mathematics learned at school. Unfortunately, tacit use of numeracy skills neither alters a negative self-image nor increases worker confidence to engage with further numeracy-related learning. It is therefore important to encourage exploration of their tacit knowledge and its conversion to 'explicit' knowledge. In this way workers will become more confident in using and transferring their existing skills and realising that they are capable of learning the additional skills required for positions of responsibility.

It was clear that most workers prefer training that is informal, immediate and 'on the job' and conducted by peers or supervisors, rather than taking the form of something which reminds them of the school environment. According to stakeholders, this is a common attitude among shopfloor and equivalent level workers, particularly in relation to maths-related skills training. Workers spoke highly of methods which gradually give them greater responsibility with support or mentoring. However, there were indications that on-the-job learning could not only be dependent on the quality of the particular trainer, but also highly procedural and without the depth of understanding required for the innovative thinking needed in the workplace. Stakeholders were unanimously in support of a combination of 'on floor' and 'off floor' training but, to ensure that workers' existing attitudes to mathematics were overcome, emphasised the importance of its being extremely practical, preferably undertaken in conjunction with immediate workplace applications and incorporating opportunities for practice and reflection. Stakeholders also suggested that, ideally, workplace numeracy training should be framed positively within training for new workplace initiatives rather than being catch-up or 'deficit model' training. It was also suggested that training should be undertaken in a non-threatening atmosphere, with a spirit of employer support and pitched at an appropriate and attainable level.

Such training would need the input of trainers with adult numeracy expertise and sound knowledge of the local enterprise. A team approach which combines these areas of knowledge at both the design and delivery stages of training programs would be ideal. However, consultation between an adult numeracy specialist and a local enterprise trainer to design the training, followed by ongoing communication during delivery, would be another effective way of accomplishing a team approach. It is possible that the team approach to training may be impractical for smaller registered training organisations and enterprises. In such instances it will be essential to provide professional development to enable trainers to increase their skills in adult numeracy training in order to ensure quality delivery. This may also mitigate the seeming shortage of workplace numeracy specialists.

Research context and issues

The importance of numeracy in today's workplace

Recent research indicates that owing to globalisation and the introduction of technology, workplace numeracy demands are growing rapidly (Hoyles et al. 2002) and will continue to increase in the coming years (National Research and Development Centre for Adult Literacy and Numeracy 2005). More workers are now engaged in maths-related tasks of increasing sophistication (Service Skills Australia 2005). Numeracy is now recognised as an essential skill in the workplace, as it enhances business goals (Balzary 2004; Dingwall 2000), assists in workplace problem-solving (Australian Chamber of Commerce and Industry & Business Council of Australia 2002) and reduces accidents and productivity loss.

The Australian Government recognises numeracy skills as an economic and equity issue, explicitly mentioning it in Australia's Vocational Education and Training (VET) Strategy for 2004–2010 (ANTA 2003). Numeracy's prominence in these government strategies is supported by evidence that adults with poor basic skills, particularly poor numeracy skills, are more likely to be unemployed or employed in manual occupations, to receive low wages, have lower promotion prospects and to have relatively low positions at work (Ananiadou, Jenkins & Wolf 2003; Falk & Millar 2001; Gleason 2005; National Research and Development Centre for Adult Literacy and Numeracy, 2005; Statistics Canada & OECD 2005). Data from Australia and the United States indicate that adults with low numeracy skills were not only economically disadvantaged, but also received fewer opportunities for training and development. However, when they do participate in on-the-job or apprentice training, there are significant personal economic benefits (Gleason 2005). Governmental recognition of the importance of workplace numeracy skills is also indicated by the inclusion of numeracy in the nationally funded Workplace English Language and Literacy (WELL) program (Department of Education, Science and Training 2005).

Peak industry bodies also recognise the importance of numeracy, referring to it specifically in two of the eight broad skill-sets of the Employability Skills Framework (Australian Chamber of Commerce and Industry & Business Council of Australia 2002) which resulted from consultations with industry. Employers identified 'using numeracy effectively' as an important facet of communication that 'contributes to productive and harmonious relations between employees and customers'. For problem-solving, a skill that 'contributes to productive outcomes', an identified facet was 'using mathematics including budgeting and financial management to solve problems' (Australian Chamber of Commerce and Industry & Business Council of Australia 2002, p.46).

Part of this workplace numeracy research project explored the importance placed on numeracy skills by the industry stakeholders, employers and managers related to the case study sites and any resultant strategies to support workers' acquisition and enhancement of relevant numeracy skills in the case study workplaces.

Definitions and conceptions of numeracy

Although the term 'numeracy' is now frequently used in policy and education circles of English-speaking Organisation for Economic Co-operation and Development (OECD) countries, it is a

relatively new word which has yet to gain popular usage in the community (Dingwall 2000). The term was originally coined as the mathematical equivalent to 'literacy', and just like literacy it remains 'a deeply contested and notoriously slippery concept' (Coben et al. 2003, p.9)—the source of ongoing debate and discussion both in Australia and internationally (see for example Coben 2000a, 2000b; Gal 2000; Johnston 2002; Johnston & Tout 1995; Marr & Helme 1991; Marr & Tout 1997; Theiring & Barbaro 1992; Yasukawa & Johnston 2001).

It is widely accepted that numeracy refers to a great deal more than basic number skills, although the notion that numeracy is merely basic number skills is an ongoing, and unfortunately common, misinterpretation. Numeracy encompasses the application of a broad range of mathematical skills, at different levels, applied to real-world purposes at home, in the workplace or in the community. It also incorporates the ability to interpret and communicate information (NCVER 2005).

There have been many attempts to express these understandings into a single definition of numeracy (for example, ANTA 2002; Gal et al. 2003). A useful definition, for the purposes of research into workplace numeracy is that of Coben:

> To be numerate means to be competent, confident, and comfortable with one's judgements on *whether* to use mathematics in a particular situation and if so, *what* mathematics to use, *how* to do it, what *degree of accuracy* is appropriate, and what the answer means in relation to the context. (Coben 2000a, p.35, emphasis in the original.)

Her description encapsulates aspects common to other working definitions and clearly stresses the highly contextualised nature of numeracy; that is, that the mathematical strategies have developed appropriately for the physical situation, the tools available, and the degree of accuracy required in particular circumstances. Coben's definition also emphasises the importance of personal confidence or 'disposition' to use mathematics in appropriate situations, an aspect highlighted as vital by the formative Cockroft report (1982): 'having sufficient confidence to make effective use of whatever mathematical skill and understanding is possessed whether this be little or much' (para 37).

Previous workplace studies (for example FitzSimons 2005; Hoyles et al. 2002; Vergnaud 2000) suggest a range of important workplace numeracy skills. The following list, derived from their findings, was used in interviews with key stakeholders and worksite managers during this study:

- calculation—with and without calculators or computers
- mental calculations/estimations
- calculation and interpretation of percentage
- measurement, such as length, volume, weight, temperature, speed
- use of ratio and proportion
- creation and use of formulae (possibly using spreadsheets)
- display and interpretation of data
- use and interpretation of graphs, charts and tables
- use and interpretation of scale drawings, plans and diagrams
- recognition of patterns and anomalies with measurement and data
- communication of mathematically related ideas
- use of computers/technology in relation to mathematical tasks
- use of mathematical ideas and concepts to model or analyse workplace situations
- use of mathematical ideas and concepts to evaluate and critique workplace practices and monitoring systems.

As indicated by the latter items, the studies found that workplace numeracy went beyond routine, procedural use of mathematical skills, to their application in 'problem-solving' situations, to cope with changing circumstances or to initiate economic and quality improvements.

The invisibility of numeracy in the workplace

Many researchers have found that endeavours to research the mathematics-related skills valued and used in workplaces are complicated by the phenomenon of 'invisibility' of numeracy (FitzSimons et al. 2005; FitzSimons & Wedege 2004; Kanes 2002; Fownes, Thompson & Evetts 2002; Hansen 2005; Human Resources and Skills Development Canada 2005; Wedege 2000, 2003, 2004; Zevenbergen 2000). By this they mean that workers are not conscious of using mathematical skills at work, even when they use them frequently. This is partly due to the negative self-image held by many workers with respect to mathematics and numeracy skills. This negative self-image causes them to assume that any operations they are capable of undertaking must be common sense rather than mathematics.

Another factor in the invisibility of numeracy is the highly contextual nature of mathematically related tasks. They are often embedded within workplace-developed routines and tools and frequently intertwined with other skills or procedures, such as information technology or written communication (Dingwall 2000; Hoyles et al. 2002). The skills in use no longer resemble the 'mathematics' performed at school, and so are not appreciated or 'recognised' as mathematics or numeracy. Nonaka and Takeuchi (1998) describe this as 'tacit' rather than 'explicit' knowledge. Tacit knowledge is usually acquired from others through observation, imitation and practice and used without awareness while focusing on a task. Lave and Wenger (1991) assert that this type of learning is commonly found in 'communities of practice' such as workplaces and is far more effective than learning which occurs in the more formal learning environments of schools and training institutions.

However, questions have been raised about the levels and type of competence that result from this type of non-reflective learning: how portable, or transferable from one situation to another, is knowledge that is not *externalised* and made *explicit*, in the minds of its users? (see, for example, Buckingham 2003; Hansen 2005; Nonaka & Takeuchi 1998). Wedege (2004) claims that this type of tacit or 'non-reflective' learning (p.9) does little to alleviate adults' negative self-image in relation to mathematics. This negative feeling is then likely to have an impact on their confidence to use mathematics and their willingness or resistance to undertake further training that involves explicit mathematics (see also Marr 2003; Marr with Helme 2002; Marr, Helme & Tout 2003). At the same time there is a mounting body of evidence that mathematics learned in school classrooms is not readily transferred when needed in the workplace. Issues of personal disposition or confidence in relation to numeracy use and further training, as well as capacity to transfer numeracy-related skills, were explored within the worker interviews for this study.

Numeracy in training packages

Questions about the invisibility of numeracy have also been raised in relation to the federal government requirement for the 'integration' or embedding of numeracy along with English language and literacy into training packages (documents which stipulate the industry competencies on which vocational education and training [VET] in Australia is based) (see, for example, Haines & Bickmore Brand 2000; Julian 2004; Sanguinetti & Hartley 2000; Trenerry 2000). Research findings suggest that English language, literacy and numeracy (LLN) competencies lacked visibility in early training packages, that trainers considered them to be insufficiently described to assist them in planning their training, and, in many cases, the inclusion of language, literacy and numeracy standards 'had made little difference to training practices and there was little or no evidence that any attention was being paid to literacy and numeracy needs' (Sanguinetti & Hartley 2000, p.32).

(A full review of the literature is included in the support document available at <www.ncver.edu.au/publications/1795.html>.)

Research questions

As indicated above, there have been some initial studies into workplace numeracy practices: the skills used and how they are adapted to very particular workplace contexts. There have also been calls for further case studies of numeracy in particular workplaces in order to increase 'understanding of how people use, modify or reject the use of school mathematics in a non-school context' (Zevenbergen 2000, p.186). However, FitzSimons et al. (2005) have observed that there is currently a gap in the research findings regarding how numeracy skills are learned in workplaces. This study sought to address that gap by investigating how workers in the case study sites learned the numeracy skills they use at work and how they personally relate these skills to their mathematics learning experiences at school.

The study explored the following research questions:

- How is numeracy conceptualised and used in workplace settings as opposed to the classroom and other domains of social and economic life?
- Are the definitions of numeracy and the concepts that define numeracy in the workplace relevant to industry's workplace needs, particularly in relation to occupational health and safety, workplace skills development and acquiring the numeracy skills to support workplace innovation?
- What are the implications of these definitions and concepts for the acquisition and enhancement of workplace numeracy skills?
- What numeracy skills do workers use in the workplace and how do they acquire these skills?
- What models (of staff development, training, work organisation etc.) would best support the acquisition, enhancement and transferability of workplace numeracy skills.

Research method

The primary data-gathering activities were desktop research and critical analysis of previous research literature, including the numeracy components of relevant training packages; semi-structured interviews (Huberman & Miles 1994) with a variety of industry representatives (key stakeholders); and case studies (Stake 2000; Fetterman 1998) of three worksites. The methodology drew on industry instructional design methods such as task analysis and training needs analysis (Morrison, Ross & Kemp 2004). These research methods were designed to:

- explore what could be learned from the existing data and associated research
- 'drill down' to examine three specific worksites in more detail through semi-structured interviews, observations and qualitative analysis (case studies)
- glean information to address both employer and employee perspectives
- explore what numeracy is used in the workplaces and how the numeracy skills were acquired
- identify any common characteristics found in the examples and models that could be used to inform future practice and directions related to the development, enhancement and transference of numeracy skills in the workplace.

Interviews in the case study sites were guided by themes derived from Australian and international research into workplace numeracy and literacy. Key stakeholders and workplace managers were asked about their conceptions of numeracy and their opinions on the importance of numeracy skills for the workforce, including trends that may have an impact on the current situation; the relationship between workplace numeracy and school mathematics; and effective numeracy training strategies for the future. The case study shadowing and the interviews with workers, supervisors and managers explored the numeracy skills used at work, workers' attitudes to numeracy and school mathematics, learning and transfer of workplace numeracy skills, as well as workers' engagement with the meaning and consequences of numeracy-related tasks. Findings related to each of these aspects are presented below.

A reference committee comprised of representatives from business groups, industry training boards, unions and training organisations (including an adult numeracy specialist) was formed to provide strategic advice to the research team.

Full details of the interview proformas, reference committee representation, and key stakeholders can be found in the support document (<www.ncver.edu.au/publications/1795.html>).

Key stakeholders

An important aspect of the study was to investigate synergies between industry numeracy skill requirements, workplace contexts and stakeholder perceptions. For this purpose semi-structured interviews were held with ten key stakeholders representing state and national peak employer organisations, relevant industry training boards, unions and several employers. (See the support document for a list of key stakeholders: <www.ncver.edu.au/publications/1795.html>.)

Case studies

Since numeracy skills are integral, in some aspects, to all industries, it was not feasible to cover the full range of industry workplaces in any one study. This research focused on three worksites, which were selected to represent a range of industries with different profiles, in terms of technology, training cultures and employees. These were:

- 'Hillside Park'[1], a not-for-profit aged care facility employs 93 workers, the majority of whom are women over 40 years of age. Many workers have limited formal education and experience some difficulties with English language, literacy and numeracy. Increasing requirements for accountability, documentation and formal qualifications in the aged care sector have led the organisation to provide a range of training opportunities.
- 'Vehicle Parts Victoria', part of a larger international corporation, is a 'high tech' engineering manufacturer of parts for the automotive industry with a predominantly male workforce of 570 employees who operate in small teams, increasingly using sophisticated technology. The company operates under well-established occupational health and safety and quality assurance systems and is proud of its training culture.
- 'Metals and More', a traditional, family-owned sheetmetal engineering factory, makes a variety of metal products and parts for a range of manufacturers. Technology is increasingly being used at the factory. It employs 70 workers, mainly English-speaking with minimal school qualifications, and has an emerging interest in quality assurance systems and worker training in order to compete with overseas manufacturers.

Each of the three case studies included in-depth interviews with a manager; a front-line supervisor or team leader; and three company employees, selected in conjunction with a liaison person at each worksite. These interviews were guided by themes discussed in the literature review. The case studies also included a process of 'shadowing' of an employee at each site (Wedege 2000) to identify tasks that may have been omitted in interviews because they include tacit or unconscious use of numeracy skills.

Workers interviewed during this study were identified by the nominated liaison person as of interest to the project because they were seen as using some degree of numeracy within their jobs. Three workers were selected in each of the sites. (See further details in the case studies section of the support document.)

Limitations of the study

This study has attempted to fill some of the gaps in existing workplace numeracy research by selecting three different industries to represent a broad spectrum of the existing Australian workforce. However, it must be acknowledged that findings from this study can only provide an indicative picture of industry. Further in-depth study would be required to build on these beginnings.

At the same time, attempts to canvas diverse sections of the workforce have prevented fully in-depth studies of any one of the selected industries. For instance, gaining a rating for the level of importance for skills in an industry sector within this broadly scoped study was problematic. In most cases, although a skill was important for the industry as a whole, it was less clear who, within the industry, needed to have the skill. Attempts to rate skills as important or very important were almost always qualified by 'it depends', referring to either the subsection of the workforce or the levels of responsibility within it. Identifying which workers will require the numeracy skills is likely to be an important issue for the future, related to widening divisions between workers and future possibilities of career progression. Therefore more in-depth studies of individual industries, or

[1] The names used for the case study sites are fictitious.

subsections of the workforce within an industry, would be highly beneficial. Furthermore, analysis of workers' responses to questions about training models and preferred methods of learning indicate that more in-depth exploration would assist to differentiate reactions to training in general and that involving numeracy.

Findings and analysis

Conceptions of numeracy for the workplace

Managers at the case study sites and the key stakeholders interviewed were in agreement that numeracy skills are vital in the modern workforce. What the term 'numeracy', as used in training policy documents, actually conveyed to them was far less clear. When asked, both groups were in accord with accepted definitions in one respect. Rather than referring to abstract mathematical knowledge, they conceptualised numeracy as including the meaningful application of mathematical skills to real situations. However, most respondents referred only to 'number' skills and calculations, and qualified these with terms such as 'basic' or 'low level', indicating a narrow expectation attached to the term 'numeracy'.

Only a minority of respondents mentioned the inclusion of measurement: some referred to reading numerical information from forms and other documentation and having understanding of its meaning, but these were not majority responses. No one referred to spatial skills of any kind; thus, reading of plans, diagrams and maps was entirely omitted from their thinking. It seemed the stakeholders' initial conceptions of numeracy could most easily be summed up as primary school level number or arithmetic skills.

Later in the interviews, when respondents were asked more explicitly about maths-related skills, including measurement, using graphs and charts, recording and interpreting data, most recognised these as necessary for workers in their sectors and supplied examples. It seemed that mention of the word 'mathematics' and the explicit unpacking of the scope and breadth intended by the term 'numeracy' were both needed in order to fully explore stakeholders' and managers' opinions of the numeracy needs within their industries. These observations suggest that the term 'numeracy' alone does not convey sufficient information to be useful at most levels of training design and delivery. It needs to be separated into component parts, such as those mentioned above, in order to convey sufficiently useful information to the reader.

Use of numeracy in the workplace

Numeracy needs of industry

When key stakeholders and managers were asked to comment on the importance of numeracy skills overall within their industry, the need for 'a numerate workforce' was expressed clearly and unanimously, with words like 'critical', 'fundamental' and 'vital' used to express the degree of importance in their minds. One union representative remarked that there is 'not a single thing we do that does not have some mathematical basis', and another saw it as 'even more important than language'.

One respondent from an industry training board expressed concern that numeracy is 'caught up in LLN [language, literacy and numeracy], but not mentioned specifically'. He thought it was interesting that most Workplace English Language and Literacy funding seemed to go to literacy rather than numeracy training and resource development, even though numeracy skills were equally important for the workforce in his industry.

The stakeholders and managers were asked to rank the importance of skills derived from Australian and international workplace numeracy research. Table 1 indicates their responses. An expanded version of this table, with examples of how the skills are applied, is included in the support document.

In many cases, although a skill was important for the industry as a whole, it was less clear which workers within the industry needed to have the skill. As one respondent from the health and community services sector observed of many of the calculation and measurement skills, 'Importance is not the same as frequency—at some stage it is important for all'. These qualifying factors mean that the numbers below are indicative only, particularly the difference between important and very important.

Table 1 Summary of the stakeholders' and case study site managers' ranking of the level of importance of numeracy skills for workers in their industry sector

	Numeracy skill	Not important	Important	Very important
1	Calculation—with and without calculators or computers			13*
2	Mental calculations/estimations		3	10*
3	Calculation and interpretation of percentage	2	10	1*
4	Measurement: e.g. length, volume, weight, temperature, speed		5	8*
5	Use of ratio and proportion	6	5	2*
6	Creation and use of formulae (possibly using spreadsheets)	3	5	5*
7	Display and interpretation of data	1	9	3*
8	Use and interpretation of graphs, charts and tables	1	7	5*
9	Use and interpretation of scale drawings, plans and diagrams	4	6	3*
10	Recognition of patterns and anomalies with measurement and data	2	7	4*
11	Communication of mathematically related ideas	3	5	5*
12	Use of computers/technology in relation to mathematical tasks		6	7*
13	Use of mathematical ideas and concepts to model or analyse workplace situations	3	8	2*
14	Use of mathematical ideas and concepts to evaluate and critique workplace practices and monitoring systems	3	7	3*

Note: * These responses include those of an employer of graduates who *design* electronic measuring systems, in contrast to the workers who *use* this type of equipment in their workplaces. This employer has rated all of the numeracy skills on the list as very important for his workers.

Items 1–9 were also explored with workers and frontline supervisors during the case studies (although presented differently in format and detail) as indicated by table 2, and are discussed in the next section along with workers' examples of how they use the skills. Stakeholder responses to items 10–14 are discussed both in the following section and later below in conjunction with data pertaining to stakeholders' predictions for future trends and the paradoxes they pose.

Numeracy used by workers

The workers interviewed at each of the case study sites were presented with a list of numeracy skills derived from Australian and international workplace numeracy research and asked to indicate how often they used them (table 2). They were also asked to provide examples of the types of tasks in which the skills were used. The following section summarises the responses of workers across the three case study sites. The frontline supervisors at each case study site were asked to respond to the same list in relation to the workers they supervised. Since they were describing the tasks of a range of workers at their sites, their responses would be misleading if combined with those of the individual workers in table 2. Their comments, however, have been used to clarify the tasks described in the text. A full description of the numeracy skills and tasks at each worksite is presented in the case studies section of the support document.

Table 2 Summary of worker responses to frequency of numeracy tasks undertaken and tools used

Numeracy tasks and tools	Never	Less than once a week	About once a week	Daily
1 Use of measurement				
Use of tape measures and rulers		1	1	7
Use of scales	2	1	1	5
Use of gauges and dials	2	1	2	4
Use of callipers and similar	5		1	3
Use of other measuring tools (e.g. teaspoon, measuring cup, air leak testers)				6*
2 Use of graphs, charts and tables				
Entering data on charts, graphs or spreadsheets	3	2		4
Reading graphs (or tables)	2	3		4
Constructing graphs	6	2		1
3 Undertaking calculations				
Adding, subtracting, multiplying			2	7
Use of percentages	3	1		5
Use of fractions	6	2		1
Use of ratio, proportion	3	2		4
Use of decimals (including money)	1	1	1	6
Use of conversion charts	6	2		1
4 Use of formulae	2	2		5
5 Reading or creating plans, diagrams and scale drawings		3		6
6 Other		1		7*

Note: * Not all respondents indicated clearly their other numeracy tasks or use of other measuring tools.

Table 2 confirms that, in these three workplaces, numeracy skills identified by previous research were used by some workers on a daily basis. It also supports the stakeholders' rating of importance for calculation and measurement skills (table 1), while the range of measuring equipment used by different workers on a daily basis confirms the contextualised nature of workplace numeracy. There is an indication that the need to read scale drawings, plans and diagrams is perhaps more important than the key stakeholders realise. On the other hand, while stakeholders rate the use of graphs, charts and tables as important, there appears to be less engagement by workers than might be expected. The following summarises the qualitative data from the case studies, explaining how the above skills are used in the three workplaces.

Measurement

Within the three workplaces studied a wide range of measurement tools are used on a daily basis, although the types of tools are particular to each site. For example, simple tape measures and rulers are used for product dimensions in manufacturing and dispatch, for room sizes, and for wound and body dimensions in aged care; verniers and callipers are used for finer lengths and thicknesses; gauges and dials are used for patient observations such as blood pressure, temperature and insulin levels (some with analogue outputs which require interpretation of scales); electronic devices are used to measure powder coating thicknesses; and scales for weighing residents, food, loads and products for monitoring, storage and transport purposes, as well as for ensuring safety for lifting and storage were also used daily.

Estimation

The degree of accuracy for measurements was highly dependent on purpose, ranging from standard tolerance levels of 0.05 or 1.00 mm in manufacturing small parts to frequent visual estimation of

load weights in relation to packing, lifting and storage or even numbers of parts off the line per minute. Workers said that the ability to estimate these types of measures is developed from years of experience handling particular products or performing similar functions in a variety of workplaces.

Estimation of time, for time-management purposes, was also an obvious skill demand for workers with responsibility for their own work areas at Metals and More and Hillside Park: judging time for tasks, juggling what tasks could fit into available time slots and prioritising according to long- and short-term timelines were common. This type of estimation was not apparent in the more streamlined Vehicle Parts Victoria.

Number skills—undertaking calculations

Both manufacturing workplaces seem to run on numbers, namely, order numbers, delivery docket numbers, invoice numbers, customer part numbers, numbers of packs, quantity per pack, dates, job numbers, shelf numbers, operator numbers, drawing numbers, machine numbers and so on. The correct copying of appropriate numbers, many with six or more digits, between different documents and computer screens and in a wide variety of formats is common, and accuracy is vital to efficiency.

Calculations involving *multiplication*, *addition* and *subtraction* performed on whole numbers (for product quantities) and *decimals* (associated with measurements and money) were also performed on a daily basis, with workers selecting, as they felt appropriate, from a variety of pen-and-paper techniques, idiosyncratic in-the-head strategies and use of a calculator. Interestingly, *division* appeared to be avoided, although strategies based on other strengths were used to get around its use. For example, 'say we have an order for 120 parts and I've got 18 sheets of metal available to cut them from. If I know that each sheet gives me 16 parts, then I calculate 18 x 16 to see if it's enough'. This strategy was usually performed in the head or with paper and pencil 'because calculators have a way of straying'. The use of division was noticeably avoided, as dividing the 120 parts needed by 16 (the number cut from one sheet) would tell him exactly how many sheets he would need, which, in this case, was only seven-and-a-half.

Often the procedures had become 'second nature', and it was clear that many workers held a huge store of job-related number facts in their memories; for instance, automatic conversions between metric and imperial for common metal sheets sizes, and multiplication constants for costing formulae.

Percentages are calculated by many, but not all, workers; for example, GST (goods and services tax) and fuel levies (10.4%) on invoices in a dispatch department, percentages of sick residents at a given time in an aged care facility or percentage of defective items off the production line in a day. With the shift to metric units of measurement, calculation involving *fractions* are no longer used, except half and quarter in relation to time sheets; nevertheless, as mentioned above, recording and calculating with *decimals* is very important.

Ratio and *proportion* were reportedly used by workers in two of the case study sites. At Hillside Park they were used more commonly than percentage, for example, when mixing food supplements or cleaning solutions in the correct concentrations. Similarly, at Vehicle Parts Victoria one of the production workers was responsible for keeping a constant ratio of water and 'flux' for his production line. In aged care, ratio was also important for mixing medications, although the trend towards pre-packaged medicine dosages is reducing the need for this application. Staff ratios such as workers to clients in aged care, or production workers to conveyor belt speed in manufacturing, also underpin many operational decisions in these two case study sites, as well as being recorded regularly and analysed as a variable in performance and quality monitoring.

Use of formulae

A diverse range of simple mathematical formulae were used effectively by many workers in the course of their jobs. The formulae were usually written in full on the relevant charts so as not to

rely on workers' memories. There was little evidence of workers understanding the mathematical reasoning behind them or questioning the procedures. For example, production workers at Vehicle Parts Victoria would unquestioningly use a many-step percentage formula (divide by the total and multiply by one hundred) even when using a calculator on which a percentage function, or interpretation of the decimal display resulting from simple division, could be considered more efficient.

Interpreting plans, diagrams and scale drawings

Workers in all of the case study sites were involved in reading some aspects of plans and diagrams. In manufacturing this usually involved interpreting plans of the products being produced, and some of these, particularly at Metals and More, were a complex array of symbols and measurements. In aged care, workers were expected to create and interpret scale drawing of residents' rooms and facilities.

Graphs, charts and tables

A marked divergence in the case studies was noticeable with respect to graphs, charts and tables. All workers used tables of product sizes, specifications, costs etc. on a daily basis. Metals and More, the traditional manufacturer, had no evidence of data-gathering graphs or charts on the factory floor. However, as expected in the competitive, economically driven environment of the modern workplace, the gathering of data and analysis of the trends occurring was the basis for work practice efficiencies in the two other workplaces studied. The associated numeracy skills were considered pivotal to their success. At Hillside Park copious statistics were collected for trend analysis as well as the resident data, which were entered regularly on individual charts and examined for changes from the normal patterns. The latter tasks were undertaken by workers at Australian Qualifications Framework (AQF) skill level III and below, while trend analysis, such as numbers of incidents, falls, or infections mapped against number of staff on duty, was performed by more highly qualified staff. However, all staff were expected to understand the resulting graphs and conclusions presented at monthly meetings. Similarly, in Vehicle Parts Victoria an array of charts on work station walls tracked the number of parts produced every hour and every shift, as well as the types and numbers of defects, and finally the percentage of defects per shift. Most workers were involved in collecting and entering data as well as making progressive calculations of cumulative totals and percentages. They were encouraged by the production supervisor to take on as much responsibility in this area as possible.

Evaluation, critique and modelling using mathematical concepts

Skills such as 'use of mathematical ideas and concepts to model and analyse workplace situations' and 'to evaluate and critique workplace practices' (items 13 and 14 in table 1) are perhaps not as universally understood as the earlier items in the table. However, they have been noted as important in overseas numeracy research literature (see Hoyles et al. 2002; Human Resources and Skills Development Canada 2005), and it was of particular interest to see how stakeholders rated the importance of these skills for workers.

There did appear to be an element of uncertainty in the responses given—one stakeholder admitted having no idea what they meant, while several others gave a middle rating but scant elaboration. One respondent commented, 'To some extent this [modelling and analysis] is a specialised area of knowledge—not done often—but it may be done by people more than they understand—its just that they don't necessarily realise when they are using mathematical concepts'.

Respondents representing industry training boards were able to supply illustrations related to the drive for cost-cutting efficiencies, quality assurance techniques and accountability for funding. For instance, 'Judgements about cost–time elements are important in increasing numbers of industries, including automotive'. Health and community services use mathematical modelling practices that would not immediately occur to people outside the industry. For example, a 20% increase in the use of toilet paper in a child-care centre is a positive measure of quality improvement, while in aged

care facilities the decrease in numbers of bandages or incontinence pads used are indicators of a decrease in the numbers of bed sores and an increase in frequency of patients who are receiving adequate attention to toilet needs. Funding decisions are based on reporting systems which are heavily reliant on input, display and interpretation of data, all based on mathematical concepts such as averages and percentiles. To understand the implications of the client information they are collecting, workers within the health and community services sector will need sufficient numeracy confidence to engage with data display and analysis.

In summary

The above findings support previous research observations (FitzSimons 2005; Vergnaud 2000) that workers need to be able to calculate with and without calculators and to have 'a feel for numbers' that allows for approximation and estimation. The findings also reinforce the contextual nature of the methods used for calculations and the particularity of the numbers and measurements that are relevant to each work situation. In addition, they highlight the increasing importance of accurate storage, retrieval, display and interpretation of data as skills needed for the workforce of the future.

Numeracy used for occupational health and safety

The study indicated that numeracy skills play an important role in occupational health and safety in two of the three case study workplaces: those in which individual judgements were made by workers in relation to tasks with an occupational health and safety risk component. In particular, visual estimation of weights in relation to lifting and storage of heavy loads and patients was important. For example, when receiving deliveries of sheetmetal at Metals and More, one worker explained that he had argued with a forklift driver who was about to lift weights which exceeded the 2.5 tonne limit for his machine and advised him to split the load. In this case scales were used to settle the disagreement. The need for these precautions was reinforced by one of the stakeholders who recalled an incident when a forklift driver placed a heavy object on a storage shelf which crashed through and killed another worker. Apart from the more obvious human implications, management was held liable for negligence. Owing to the automated and systematised approach at Vehicle Parts Victoria, little personal judgement of this nature was left to the workers.

One key stakeholder representing health and aged care highlighted that two-fifths of their industry's 'five rights mantra' for administering medication (right person, right medication, right dosage, right time, and right route) have numeracy skills embedded. For example, correctly interpreting the frequency and times to administer medicines (right time) is vital. Measurement skills and ratio and proportion calculations are also important for mixing medications (right dose) because 'being out by a factor of ten can kill a person', although the trend towards pre-packaged doses of medication is working to minimise this risk. Ratio, proportion and measurement skills are also important for preparing antiseptics and cleaning solutions in health and community work.

In addition to routine measurement and calculation skills related to occupational health and safety some stakeholders commented on aspects of data display and analysis. Union stakeholders were keen that workers in all industries engage with data that were distributed in relation to workplace occupational health and safety in order to become more aware of safety issues.

Interestingly, several of the employers who were interviewed saw no numeracy-related skills involved in occupational health and safety for their workers.

Industry innovations and future trends

Effects of automation

Many key stakeholders expressed uncertainty about the numeracy demands on workers of the future. Changes taking place in work practices which are driven by cost-efficiency measures and technological 'advances' mean changing, and possibly increasing, demands on workers' numeracy

levels and skills. It is not yet clear, however, whether in the future these changes will mean an increase in numeracy demands for a few and less for others.

Trends towards greater automation in manufacturing and pre-packaging of medicinal doses in aged care mean that, at first glance, base-level workers may perform fewer routine numeracy-related tasks. The Vehicle Parts Victoria production supervisor explained that 'in this industrial situation lots of stuff is made easy' [sic]. Examples included digital readouts with decimal displays; simplified diagrams; and pre-calculated amounts of chemicals listed on charts rather than relying on workers using ratio and proportion computations.

However, on reflection, several stakeholders surmised that, although the workers would be required to perform fewer routine measurement tasks, they would still be expected to monitor and make judgements about accuracy of the medical doses or mechanised outputs: judgements which will require understanding, not only of the measurements, but also the 'big picture' or wider context of its use and importance. As an industry training board chief executive officer explained, 'They need to understand what's around their job so that they can see when something is not quite right'; they need to understand the significance of numerical output in order 'to appreciate what magnitude of number to expect rather than blindly accepting readings and measurements', whether from machines or others in the chain of responsibility. He said that 'a more generically skilled worker is needed' to know what 'you expect to see and … when it's out of whack … to stop the machine and problem solve the cause—it takes knowledge to be able to question things'.

The production supervisor at Vehicle Parts Victoria explained that he would prefer it if the team leaders thought more about the purpose of tasks and so took more personal initiative, for example, creating their own charts when they saw production problems that needed monitoring more closely within their area. Establishing charts on their own initiative would require greater numeracy skills from workers than merely filling in charts created by others. They would need the confidence to make decisions about suitable scales, frequency of measurement, sample size and clear graph labels. They would also need to be confident of their ability to interpret the resulting data.

Increasing use of data in industry

Data gathering and analysis is now a major tool for monitoring costs and work practices in modern workplaces. Most workers are involved in data collection of some kind, as a Vehicle Parts Victoria production supervisor explained, 'because to fix anything—to know where you stand you've got to be able to measure it [collect and analyse production data]'. Other comments included, 'Establishing patterns is a key to change—things come from being able to aggregate data—looking for patterns and understanding what is happening with the workforce is important in health and aged care'. 'Five years ago I would have said not very much, but with the development of technology the expectation of people being able to use and understand things like graphs, charts and tables changes substantially.' While quality concerns, beyond the collection of data, were seen by several stakeholders as purely the domain of management, others acknowledged that these responsibilities were being delegated to lower-level workers wherever possible. Accompanying these practices is an increase of documentation in workplaces, with leading hands or team leaders given more paper work, being expected to read and interpret manufacturers' specifications and tolerance limits for equipment, completing daily progress charts, preparing reports, and needing to communicate with others about their observations and reports. Also, in aged care, constant engagement with data display and analysis of incidents in relation to staffing ratios, health changes and resident care are expected of workers in relation to quality assurance, evaluation and innovation.

These responses suggest that stakeholders and supervisors see the need for workers who are willing and able to go beyond defined routines and procedures to the type of thinking that contributes to critique and thus innovation in the workplace. The need for these less definable aspects of competence, including the confidence to use numeracy skills when appropriate, has been observed in earlier workplace numeracy studies. Buckingham (2003) describes 'decision making' judged on a scale of 'readiness to act'; Wedege (2004) refers to 'readiness for action and thought'; FitzSimons

(2005) expresses 'a disposition to make sense of available data … and a positive creative approach to problem-solving' (p.82) and Hager (2003) talks of equipping workers for making holistic 'judgements'. Coben's (2000a) definition of *being numerate* also refers to being confident with judgements relating to choosing and using numeracy skills.

Isolation of workers

Another clear trend emerging from stakeholder interviews is that some workers are becoming increasingly isolated in their jobs, with less collegial support and supervision, at the same time as having to take on wider responsibilities. For example, increasing specialisations in industry may mean multi-tasking in one dedicated area, where employees are expected to operate, monitor, repair and even train others to use specialised equipment. In health and aged care, attending to clients at home is becoming more common. In this situation multi-tasking may include reading the client's care plan, administering the correct dosage of medicines, checking medicine use-by dates; taking and recording observational measurements (data), writing a care report, invoicing the clients and collecting money for the services performed, all very distant from personal supervision or support from other workers.

These findings are at odds with observation relating to social distribution of skills and tasks in the workplace (Jackson 2005; Waterhouse & Virgona 2004). Although groups of people may be able to perform beyond the capacities of the individuals within them and to develop their skills through social interaction, the trends described above are likely to deny this possibility. Instead, they demand individual confidence and competence at all stages of the work.

Computerisation and hand-held technology

From key stakeholders' observations it is clear that technological advances are driving workplace changes, particularly in relation to computerisation, and that workers need to be able to deal with these changes. For example, computerised measurements and manufacturers' specification charts are replacing instinct and experience for mechanics when making judgements about car performance. To be more efficient, the mechanics also will need to multi-task, namely, to follow circuit diagrams; to diagnose faults; to consult and interpret manufacturers' specification tables and charts; and to time themselves; and to balance when to cut losses by deciding a repair is not cost-effective and instead replacing the component or vehicle.

The introduction of hand-held technology such as 'palm pilots' was another innovation noted by stakeholders. In the near future, in aged care, it is predicted that most of the tasks described above for home care of clients will be performed using a palm pilot connected to a central database. Reading the care plan and performing calculations related to services and charges, as well as inputting data, will rely on the palm pilot. The central computer will have the capacity to aggregate data and create immediate updates on patient details and medical observations, as well as records of the type and length of service provided.

As well as their use in aged care, hand-held devices are increasingly being introduced into other professions, such as the building trades, where they can be used to take and record household measurements, instantly perform calculations related to likely costs and amounts of material and to create invoices and quotes on the spot. Similarly, fire fighters are increasingly using hand-held 'global positioning system' equipment to perform their work functions (Hayes, Golding & Harvey 2004). Unlike computers, hand-held technologies do not rely on keyboard operation but more on graphic displays. Further research would be advisable to ascertain the relationship between the skills needed for each technology and whether computer skills will be superseded by those required for palm pilots and the like.

Implications for workers' numeracy

Current and future changes in workplaces, as described above, present a paradox or tension in relation to future numeracy demands. In the future, workers may not use numeracy skills and

knowledge to undertake repetitive tasks, such as measuring each product made or medicine dose administered, but they will need to make critical judgements which depend on having those skills.

> From my meetings with employers I would say that they want workers who can understand overall processes so they can make critical judgements—to make sure things are OK even when machines are doing a lot of the mundane measurement tasks—they need to be skilled beyond the readout of the machine. (TAFE workplace training consultant)

At this stage the key stakeholders could only guess whether the responsibility for making critical judgements would fall on all workers or whether we will see a widening gap between the majority of workers and a select few. One industry training board chief executive officer expressed the dilemma: 'Will there be a split between diagnosticians and routine workers?' What was clear, however, was that workers who aspire to promotion will need broader skills, knowledge and understanding than required at present, particularly in relation to the use of technology for data analysis and display, and communication of mathematical ideas: 'It's a management or supervisory skill—important for workers to understand not just what they are doing but why they are doing it—so supervisors need to communicate mathematical concepts where these are intrinsic to the work being done.' This is likely to be a significant issue for the future, related to widening divisions between workers and the future possibility of career progression.

One stakeholder from community and health industry training expressed a concern about a tendency in schools to assume that the sector does not require mathematic skills, only 'people skills', so those with mathematical inclinations are steered elsewhere. Since the increasing focus on improving wellbeing through early intervention, monitoring and home care means that all levels of the workforce need numeracy skills, he felt it was important to change this view of the sector.

Relationship between workplace numeracy and school mathematics

Coben's research into adults' 'mathematics life histories' reveals that many adults have such negative perceptions of themselves in relation to mathematics as experienced at school that what they cannot do they regard as mathematics, while what they can do they see as 'common sense' or non-mathematics. The mathematics that they can do, such as measurement or numerical calculations, is taken for granted because to recognise it as mathematics would contradict their self-image as unsuccessful mathematics learners (Coben 2000b). Wedege (2004) suggests that those people who say they do not need or use mathematics only refer to school mathematics, while the numeracy they use at work tends to go unrecognised.

These observations prompted exploration of the relationship between school mathematics and the numeracy skills of workers. Stakeholders and managers as well as workers were consulted on this issue. Diverse opinions were uncovered. A number of stakeholders assumed that schools successfully developed the basic number and measurement skills needed by shopfloor-level workers. Although not directly related to *school* education, it was interesting to note that one automotive industry employer saw mechanics apprenticeships as adequate preparation for the job, and another stakeholder, an employer of engineers and electronic designers, said he thought that young graduates received excellent mathematical training in their degree courses.

Other comments from stakeholders were less positive about the role of schools in numeracy education. One comment related to students in business courses (traineeships and degree level) leaving school without the mathematical knowledge and confidence required for the courses studied. They often dropped out to avoid compulsory mathematics-based subjects. Another stakeholder commented that schools were not providing adequate foundations for numeracy because of the necessity of covering too much mathematical content too quickly, which meant that skills were largely taught without reference to use, purpose or meaningful application. 'The kids need to know why they are learning the stuff—not have it presented in abstract and theoretical terms.'

The feelings of the workers interviewed varied about the usefulness of school mathematics; that is, from seeing absolutely no connection to the maths used at work, to identifying the transferability of some school maths skills and, for some, feeling that this validated their school experience, even though they had not felt positive about it at the time. It seemed that, while all of the workers in the case studies drew on primary school maths to some extent, only those who were confident in their maths skills realised this without prompting. Some needed prompting to force a realisation that they possessed any such skills, let alone consider the possibilities of transfer. All but one of those interviewed had negative responses to mathematics education at school. Two of the sheetmetal workers had no high school mathematics education at all.

A response by one of the aged care workers on the usefulness of school mathematics at work typified a number of worker opinions. For her, foundation skills from primary school maths, which she loved, were directly relevant to work requirements. She saw much less connection to secondary school maths, which she studied to Year 10 but stopped because 'the teacher couldn't relate it to real life'. She said she'd enjoyed percentages, but hated algebra because she saw it as useless for life. Her need to be able to see a relationship between maths and real life was echoed by most of the workers; for example, 'I only did maths to Year 10, I couldn't stand it—fractions and all that stuff—I didn't pay attention. But I did do accounting—didn't mind that.'

The inescapable conclusion to be drawn from these comments is that, to avoid lack of interest and subsequent rejection, mathematics needs to be made relevant to the learners. It may be the lack of relevance or connection to the learners' perceived future life and work realities that has led to observations from Vygotsky and his followers that maths taught in school is not readily transferred when required in vocational situations (see, for example, Evans 2000; Nunes, Schliemann & Carraher 1993; Brown, Collins & Duguid 1989; Lave & Wenger 1991; Martin, LaCroix & Fownes 2005; FitzSimons et al. 2005). However, given the broad spectrum of future occupations within most secondary school classes, relevance to particular industries will not necessarily capture the interest of all students. Discussion of a wide range of links may be called for.

Dingwall (2000) suggests that in workplaces it is necessary to have a high level of competence in particular skills rather than an approximate understanding of a broad general mathematics curriculum (p.12). To some extent, his assertions are supported by this study, which indicates that numeracy skills are used in a very particular or contextualised manner in each workplace. However, as Vergnaud (2000) has pointed out, there are many skills that are used 'again and again in the routines used in the workplace' (p.xviii). These skills include ratio and proportion; reading and interpreting graphs; and evaluation and approximation. Vergnaud questions whether the amount of time given to these skills in school curriculum is adequate in providing a solid foundation for their use in the workplace. School learners need time to become confident in using these skills. Also, as suggested above, it would assist learners to transfer the skills if they were given an opportunity to explore their applications in occupations relevant to the learners.

Transfer of numeracy skills—work and life

Concerns relating to the difficulty of transfer of skills from one context to another, as described above, prompted this study to probe these issues with the workers during the shadowing and interview processes. Although the findings relating to transfer from school to work were not clear cut, there was evidence that transfer of skills and knowledge did take place between workplaces and between life situations and work. Workers learned the basics in one place and adjusted or built on them in other contexts; for example, product-counting systems, medical procedures and paperwork. 'In a new place the forms will be set out differently—you just have to look harder at first until you recognise what everything is.' One worker explained that a great deal of knowledge gained through prior work experience was fundamental to the type of work he did now and that he could use it from one job to the next: 'Dies, spring loaded punches and settings all work on the same theory, even though the parts are different somewhere else.' This worker, who had minimal schooling, said

he could barely read, write or 'do tables' when he left school. He said he had bought an old computer for home, learned to use it and transferred these skills to the workplace. Incidentally, he remarked that it had also helped with his spelling. Commenting on another of his work functions, 'inward goods', he expressed confidence that having learned the procedures on the job in this company, he could transfer his knowledge of the product and process to similar work settings: 'I'm OK with metal because I know the goods'.

One worker in aged care had taken on a variety of extra duties, including resident craft classes and membership of the building committee, both of which involved many numeracy-related tasks such as sketching rooms and furniture and enlarging craft work patterns for sight-impaired patients. She reflected that when learning to draw room layouts to scale she had benefited from a combination of discussions in meetings, her primary school maths, and skills she had learned from her grandmother, a dressmaker who had helped her copy patterns for dolls' clothes. She also commented that she had used these newly acquired skills at her child's school to help them gain accreditation in terms of playground equipment and space allocations.

This study has indicated that the workers who were able to reflect on, and describe, the numeracy-related skills they had developed in the workplace were confident in their ability to transfer them to other situations. For some workers, the unconscious use of numeracy skills, or its invisibility to them, made it more difficult to explore questions of transfer.

Beyond the procedural use of mathematical operations

As indicated above, both this study and former workplace numeracy research indicate the need for workers with 'readiness for thought and action' (Wedege 2004) who are confident to use numeracy skills in problem-solving situations. This study made attempts to explore whether workers in the case study sites use skills which might be described as 'judgement' or 'problem-solving' beyond the routine numeracy-based procedures of their work and whether their work environments supported the application of new skills and encouragement of risk-taking (Jackson 2005).

Workers across the three worksites felt they were encouraged to think about how workplace procedures could be improved. Those in the aged care facility and Vehicle Parts Victoria considered their workplaces proactive, having introduced initiatives for encouraging workers to suggest improvements, including team discussions and monthly staff meetings at which continuous-improvement measures are discussed. Workers at Vehicle Parts Victoria explained that, when manufactured parts went outside specifications, they were encouraged to 'problem solve' before seeking help from team leaders or supervisors. This might involve making adjustments to machine settings or identifying the source of faults. In the more traditional manufacturing environment at Metals and More, workers appreciated being able to make changes, at least within their own sections, and were happy to feel they could question systems and procedures with the production manager.

Some workers in the manufacturing plants showed individual initiative by streamlining numeracy-related tasks and establishing new systems to save time and hence money. For example, one worker at Vehicle Parts Victoria said he had simplified the company's product-recording sheet in a way that made it easier for everyone to use. A worker at Metals and More had introduced different tallying, labelling and coding systems for the stocks of sheet metal in his area in order to make leftover stock easier to locate and therefore prevent wastage; another had created a chart of common product dimensions to save her time in freight calculations. These examples illustrate workers using numeracy they feel confident with in order to solve problems relating to saving time and money, outcomes they perceive as meaningful.

Although identification of problem-solving as a generic skill for workers is popularly used to justify the inclusion of *mathematical* problem-solving in the school curriculum, some researchers observe that, in fact, problem-solving in the workplace differs significantly from that taught at school. One aspect of difference is the motivation for undertaking the task, since problem-solving in the

workplace is focused on a practical outcome, rather than being an end in itself or generating further mathematical knowledge. In addition, in a work situation the problem is usually 'owned' by, and has meaning for, the person solving it, rather than being presented by a teacher. In school mathematics problems have absolute and correct solutions, but there are no real consequences if a wrong answer is given. However, in the workplace, incorrect solutions can have serious and costly consequences, while the degree of accuracy or exactness of the outcome is not absolute, but negotiable according to the circumstances (Martin, LaCroix & Fownes 2005).

Although examples of workers using numeracy to solve real problems were observed, the rote performance of procedures without understanding were also observed; for instance, one worker described 'taking away or adding the dot' to convert between centimetres and millimetres during volume calculations but had no clear understanding of the resulting units, only that 'it works'. In spite of their lack of understanding of the mathematical reasoning behind numeracy tasks, it was clear that most of the workers could see the consequences of the numeracy-related procedures within the 'big picture', and took a great deal of responsibility for ensuring these tasks were done well. The aged care workers were all extremely aware of their responsibilities for the wellbeing of their clients. It seems that awareness of consequences and regarding tasks as serious and meaningful do not necessarily lead to concern for understanding of mathematical concepts. Whether or not problem-solving skills and the capacity to make holistic judgements will be the result of further school mathematics education, as advocated by FitzSimons et al. (2005), is also problematic.

Workplace learning and training

Stakeholders' perspectives

When stakeholders were asked their opinions on the most effective learning methods for workers, their immediate responses were overwhelmingly in favour of *practical* or 'hands-on' approaches: 'being involved is much more effective than reading about it'.

Commenting on the list of possible training options presented to them, most stakeholders thought that peer training, observation, formal training (in-house and external), mentoring schemes, simulated training environments and group discussions of case studies all had their place in workplace training, depending on the type of task or learning that was required. However, strong reservations were expressed about formal training. The stakeholders were also adamant that, if formal training was used, it needed to be 'less school-like' and 'not in a classroom'; furthermore, it was important not to create an environment reminiscent of school because workers in lower skill level jobs often had very negative associations with school—there was 'too much baggage!'.

Opinions differed about whether 'on' or 'off the job' training was more effective. One union representative expressed her opinion that formal training in the workplace was often the least effective because proximity to the workstation meant many interruptions and a consequent lack of participant focus. An industry training board representative remarked that formal training outside the job was often ineffective because it failed to make direct links to the person's workplace, claiming that training had to be 'more tangible and real'.

Most stakeholders favoured observing others and demonstrations by peers or supervisors for training in practical tasks. However, some union and employer representatives expressed reservations, claiming that purely on-the-job training can suffer through lack of available time in the workplace and the varying standards of personnel doing the training. As one union representative said, 'The training is only as good as the trainer'. In addition, lack of background knowledge and errors of understanding are easily passed on unchallenged when learning on the job is the only method of training. She said that although 'it's possible to pick up bad habits without realising … it is important to learn from high quality people'. Her other reservations regarding peer training included concerns that if workers' background skills are missing, the approach was unlikely to be successful. Reservations were also expressed over the quality of supervisors as trainers, as well as

the possibility of invoking 'other emotional factors', since workers did not want to 'expose themselves as an idiot with the boss'.

These latter observations are likely to be relevant to numeracy training in particular, since there was general acknowledgement that some elements of formal training were necessary for conceptual development, including reflection and discussion of mathematical concepts and their applications.

As described earlier, there were many instances of procedural numeracy observed during the case studies. These rote-learned procedures appeared to be a result of training, by co-workers or peers, in a way that it did not necessarily address understanding of the underpinning concepts or knowledge. As a result, it seemed that workers did not have sufficient understanding to either critique the processes or to transfer the skills to other circumstances. Perhaps if a mathematics-aware trainer were involved at some stage of the training, workers might be encouraged to engage with questions such as: what are we doing when we shift a decimal point? Or does calculating the goods and services tax before or after adding the fuel levy make a difference to the final freight cost? Discussions like this should allow workers to gain a deeper and more confident grasp of the numeracy procedures they are undertaking. However, they would require off-the-job training time and a thorough awareness of workers' roles by the trainer.

A combination of formal training with on-the-job application seemed to be universally advocated by stakeholders, with reservations that it should be done 'in a very supportive atmosphere because those who don't have it [mathematics] are frightened of it—it is strongly emotionally charged!' Numeracy training also:

> … needs to reinforce what is learned on the job and vice versa … It is important that numeracy training is meaningful for workers because it should be about empowering them within the workplace so they can realise some career progression.
>
> (Industry training board representative)

Industry training board representatives agreed that numeracy training needs to be meaningful and experiential, with strong links to immediate work situations and opportunities for reflection on the applications. An 'experiential learning cycle is ideal', and so numeracy training should always be undertaken in conjunction with practical and immediate workplace applications. For health and community welfare areas like aged care, this could be done 'by simulating workplace situations, for instance, skills such as estimation and proportions could be rehearsed in practical situations without jeopardising real patients. Do, reflect, get it right, rather than doing it with clients the first time round.' To this end there were suggestions that numeracy learning would be best served if the skills were explicitly identified within the practical competencies of the training packages, rather than taught separately. However, it would mean that 'general trainers are likely to need to increase their skills and awareness about effective numeracy training'.

Union representatives stressed that encouragement and a positive attitude by employers was a necessary factor to successful training strategies. This includes training that is manageable in work time rather than out of hours and sufficiently formalised to be recognised at industry level to ensure qualifications are portable. There was some concern that, although training that provides opportunities for independent study is preferred by people with particular learning styles, there is a tendency to expect it to happen in workers' own time. Role models and mentors supporting participation with supervision and a gradual increase in difficulty of task and responsibility, like that associated with apprenticeship training, were also identified as effective.

A chamber of commerce representative thought that numeracy training, where possible, should be framed positively within training for new workplace initiatives such as quality systems training, rather than being identified as catch-up, or 'deficit model', training. It should also encompass the principles of adult learning. In accordance with these principles, numeracy training should also be based on an understanding of the levels of the individuals in the group, as well as what is needed by the employer, and pitched at an appropriate and attainable level.

Worker perspectives

Interviews with workers during the case studies certainly corroborated stakeholders' preferences for practical learning strategies. Most workers were very clear that they preferred to learn on the job through demonstrations by fellow workers, team leaders or technical staff from other departments, with ongoing support and the opportunity to ask for further assistance if needed.

No one interviewed within the manufacturing environments was enthusiastic about learning in a classroom setting. Vehicle Parts Victoria works hard to promote a learning culture, encouraging workers to undertake the Certificate II in Automotive Manufacturing, with incentives of pay increases and opportunities for advancement. However, the three workers interviewed expressed no interest in taking these formal training opportunities, particularly in the independent mode used at the company. They said that they didn't 'like manuals or folders of work to read and go through' and that they were much happier learning on the job. They did make positive reference to attending an initial four-hour training program on 'measuring and scales' undertaken during a shift, with a certificate of attainment issued on completion.

At Metals and More, two of the case study interviewees, both of whom had attended only about one year of secondary education, were asked to participate in a recent numeracy training program delivered on site by a local technical and further education (TAFE) provider. It was obvious from their comments that the experience had been threatening to them, apparently awakening strong anxieties associated with past negative school experiences. One female worker said, 'She was a really nice lady but I really used to dread Thursdays'; while a male worker commented, 'I felt a bit agitated, a bit threatened. I wondered why I was learning this stuff—after all I'm nearly 48 years old.'

Some of their comments indicated that they were looking for a direct relationship between their current work area and the training, both workers spontaneously mentioning aspects of disconnection. The female mentioned above said, 'I would rather have done something useful … it was mainly the men's stuff—for the Numerical Control Room'. The male referred to above remarked, 'When they did the course here they worked in centimetres which we never do on the factory floor'. In spite of the negative emotions provoked by attending formal classes, he said that mainly the experience had 'helped get my mind going', as well as 'learning to calculate areas with π'. The female worker, on the other hand, reflected that she must have learned something because *the teacher said* she had passed. These very different reactions possibly relate to the markedly different self-images and confidence in using maths skills.

Experienced numeracy teachers have noted the importance of the connection between numeracy learners' awareness of their existing skills and new learning (Marr with Helme 2002). This awareness, or the lack of it, played an important role in the development of their personal numeracy identities. According to Marr (2003), awareness of existing skills and knowledge, and making personal connections to their own lives and work contribute in a two-way relationship to the confidence of adults in using numeracy in relevant situations and in continuing with their learning. As one of the teachers interviewed by Marr and Helme pointed out, it is not enough for a teacher to tell you that you can do something; you have to believe it yourself.

Numeracy in training packages

Currently, two approaches have been identified to integrating numeracy in training packages. In one approach numeracy skill requirements are *implicit*: embedded but not specifically spelled out. For example, the Certificate II in Automotive Manufacturing has no elements or performance criteria directly related to numeracy. The range statements include numeracy-related tasks such as 'weighing and measuring materials to specified amounts'. However, the necessary underpinning knowledge of decimals, reading and interpreting analogue scales and the like are not included, so are likely to become invisible. As a consequence, trainers may not realise the need to address this underpinning knowledge for some learners and, hence, do not plan for this within their training. This observation

supports earlier findings by Julian (2004), who found that the main advantage of embedding employability skills, which include numeracy, in the units of training packages is that 'teaching and assessment of the skill becomes highly relevant and contextualised' (p.91). However, the main disadvantage is that they are subsumed by the vocational content. 'Embedding any generic or employability skills in the performance criteria, evidence guide or underpinning skills and knowledge acknowledges that the skills can make them very easy to ignore or forget' (Julian 2004, p.91).

The second approach to integrating numeracy in training packages presents the numeracy skill requirements explicitly, as separate units of competency, such as 'Perform engineering measurements' and 'Perform computations' in the Certificate III in Engineering—Production Systems. In these competency descriptions mathematical topics are listed under 'required skills' and 'required knowledge' with little or no emphasis on linking them to workers' current jobs. This risks the same problems inherent to secondary mathematics education: the possibility that trainers could fail to make relevant links to the learners' reality and the practical requirements of their jobs, and which would give workers little motivation to learn the skills.

The embedded approach was recommended as a strategy by several of the key stakeholders interviewed during this research and was given particular emphasis by a representative of the Community Services and Health Industry Training Board. They suggested that this approach would give the numeracy skills contextual relevance to overcome learners' association with mathematics as abstract and irrelevant. Clearly, the skills would need to be given prominence, with underpinning knowledge and strategies for their development spelled out in more detail than in existing training packages.

Implications for workplace numeracy training

It is clear from the findings that the numeracy skills of measurement, number calculations, reading and interpreting diagrams, and using simple formulae are necessary in all of the workplaces studied during this project. There are increasing expectations that workers engage in collection, display, analysis and interpretation of data—not only for efficiency, product quality, or patient care matters, but also those of of occupational health and safety. It is also apparent that employers want employees who are proactive workers 'ready for thought and action' (Wedege 2004) and who will show initiative, solve problems and appreciate the 'big picture' of their workplace. All of these observations are in accord with Coben's definition of numeracy (Coben 2000a), which emphasises the confident use of judgement in the appropriate application of a range of mathematical skills. Acquiring these numeracy skills is important for all new and existing workers. The challenge is how this learning can be effectively supported.

Conceptions of numeracy

This study has indicated that the use of the single term 'numeracy' limits the conceptualisation required at most levels of planning and implementation. The word may be a useful umbrella term at policy level, since its link to literacy in LLN (language, literacy and numeracy) *may* mean that numeracy is entitled to a small share of the funding designated for language, literacy and numeracy purposes, for example, as a component of the federally funded Workplace English Language and Literacy (WELL) programs. However, a tendency for numeracy to become invisible and, hence, neglected in the literacy and language arena is apparent both from stakeholders' comments and from the many supposed language, literacy *and numeracy* research reports that contain little specific mention of numeracy (for example, Waterhouse & Virgona 2004; Sanguinetti & Hartley 2000). It is clear that, for numeracy learning and use in the workplace to receive the necessary attention in the training agenda, it must first be extracted from within language, literacy and numeracy. As it gets further from policy to practical implementation, more explicit unpacking of the scope and breadth of numeracy will be needed to expose the true training needs. This research indicates that it can be helpful to unpack the component sub-sections such as measurement, calculation, ratio and proportion, use of formulae, graphs, charts and tables, scale drawings, plans and diagrams. However, more work is needed to articulate and highlight the less obvious aspects that are beyond the procedural application of skills, such as problem-solving; communicating mathematical ideas; and modelling, analysing and critiquing workplace practices; and clarifying the place of these aspects within training.

Numeracy within training packages

As indicated in the previous section, two approaches have been identified to numeracy in training packages: the implicit or embedded approach which does not spell out, or acknowledge, the necessary underpinning numeracy knowledge and skills; and the explicit approach which lists the skills as separate units of competency with long lists of mathematical topics but little or no emphasis on linking them to workers' current jobs.

Both approaches raise important issues similar to those discussed in respect to workplace training, including the following questions.

- ✧ Who is best able to design and deliver appropriate numeracy training?
- ✧ How can it happen without alienating groups of learners who are likely to be anxious about mathematics as a result of past school experience?

These considerations are worthy of further investigation, discussion and debate.

As reported in the findings and analysis section, several key stakeholders favoured an approach which embedded numeracy competencies within vocational competency standards in order to make them contextually meaningful rather than abstract notions. However, as discussed earlier, this risks the numeracy skills becoming invisible and ignored during training. In order to follow their suggestions but make the numeracy visible and explicit, it may be helpful to name the numeracy skill, as well as describing its contextually specific use and terminology. It may also be beneficial to provide reference within the training package's documents to appropriate resources which support the development of numeracy skills. An approach of this kind may, in part, assist vocational trainers to appreciate their existing numeracy skills, instil confidence to support their learners' numeracy development and also alert them to when it may be necessary to work with a numeracy specialist. Further research into this contextualised, but explicit, approach to numeracy in training package documentation is recommended.

Informants for future workplace numeracy input

One observation made by this research team is perhaps predictable, but nevertheless worth mentioning for consideration in future policy-making forums. It appeared that the higher the position held in the hierarchy of an organisation, the less detailed the understanding of the actual numeracy use and needs of workers. It was the personnel with regular, direct contact with the workers as they went about their daily and weekly procedures who were the most knowledgeable informants in this study. This observation applied to union groups, employer representative bodies and individual companies. A notable exception was the industry training boards, whose executive officers seemed particularly well informed about the numeracy needs of a broad spectrum of workers and the associated numeracy training issues. This highlights the need for the people organising training, writing competency descriptions and advising government policy on training to have a thorough and grounded understanding of workplace skill requirements.

Training numerate workers

As described in the findings, most workers prefer training that is informal, immediate and provided on the job by peers or supervisors. They speak highly of methods that gradually give them greater responsibility, including support or mentoring, but resist anything that reminds them of the school environment. According to stakeholders, this is an attitude common among shopfloor and equivalent level workers, particularly in regard to maths-related skills training. Most workers had negative reactions to secondary school mathematics, which they saw as abstract, irrelevant and useless, and displayed varying signs of anxiety when it was discussed. Fundamental arithmetic skills at which they were competent seemed to be taken for granted. Even when they had learned new skills in the workplace, there was a tendency for the less confident not to recognise their skills as mathematics, rather viewing them as part of the job, or common sense. Studies have shown that reactions of anxiety and self-negation with respect to mathematics are typical of adults internationally (for example, Wedege 2004). What they cannot do, such as fractions, long division or algebra, they regard as mathematics, while what they can do they see as common sense (Coben 2000b).

Research by Marr, Helme and Tout (2003) also indicates that a negative numeracy self-image works against the desire and capacity to engage with further numeracy-related learning. Their

recommendations suggest devoting some time to discussions which encourage learners to reflect on and identify their existing and newly developed numeracy skills, rather than continuing to focus on their failures. In the workplace, some off-the-job training time would be needed for this exploration of tacit knowledge and its conversion to explicit knowledge in order to enhance workers' confidence to use and transfer their skills.

What then are the implications of the above for training existing and future workers? This study indicates that on-the-job learning and training methods have been effective for many purposes. However, encouraging proactive workers with the up-to-date numeracy skills desired by employers would seem to require more than a 'just in time' approach to training. While it should be linked to practical, job-related applications of all workers involved, it would also need to include some time off the job for discussion, new conceptual learning and reflection.

Integrating numeracy training

Suggestions for integration of numeracy skills into positive new initiatives, such as continuous-improvement processes, or embedding the skills *more explicitly* (contextualised and detailed) into appropriate vocational competency training, have been put forward by stakeholders. This type of integration has several advantages. It would:

- avoid words like 'mathematics' or 'numeracy' that provoke possible 'maths anxiety'; this would avoid fear reactions that make many adults unwilling to participate
- avoid singling individuals out for extra numeracy help and the embarrassment that such 'deficit model' training carries
- be in accord with workers' preferences for a visible relationship between the numeracy skills and their work responsibilities.

Timing of such training would be, of course, important to preserving realistic connections to the workplace. As recommended by action learning guidelines (for example Mumford 1997), it would be necessary to ensure immediate application and practice in the workplace, even if only applied to a pilot scheme or workplace simulation. However, remembering the stakeholders' opinions on the importance of the trainer to successful training outcomes, there are many potential obstacles to the success of this approach. Many trainers and vocational teachers have their own anxieties about maths. They may have developed sufficient competence to apply the skills themselves, often learning them on the job to a point where the skills are second nature. However, often trainers do not have sufficient confidence in their underpinning knowledge or relevant language to be able to communicate mathematically related ideas to learners. This lack of confidence and knowledge can lead to two undesirable approaches.

- Mathematical skills and concepts can be treated in a procedural, rote-learning manner without attention being paid to underpinning concepts and knowledge and therefore risk passing on uncertainty and misunderstanding.
- Mathematical concepts might be addressed using methods which replicate school approaches, the same techniques which have previously alienated these learners.

Professional development relating to adult numeracy skills and appropriate teaching approaches would help to alleviate these issues. A model of training, using a team approach, also seems to stand out as answering many of the dilemmas raised to date.

A team approach to numeracy training—using adult numeracy teacher expertise

Inappropriate approaches to numeracy training are more likely to be avoided if personnel with adult numeracy teaching expertise are used within the training team. However, numeracy teachers from outside the workplace would need to work alongside internal trainers and/or local technical experts

(at least at the training design stage) to ensure that they are 'keeping it real' or connecting with the realities of the workplace. This can include:

- using authentic workplace charts and documents within the training
- making links between mathematical terms and concepts and the local workplace terminology
- validating workers' different idiosyncratic methods by making links between them and other accepted procedures
- applying adult learning principles which use the familiar, practical situations of the learners as foundations for building general concepts and skills and then exploring how these are transferred to new workplace applications.

The participation of numeracy teachers in training teams would carry additional advantages. They would be aware of adult numeracy training methods and resources, which are designed to be very different from traditional mathematics classroom methods. They would also be available to support vocational trainers to address the numeracy needs of learners and to support workers who want extra assistance with underpinning skills as part of the training.

Learners' confidence and transfer of numeracy skills

There are indications in this research that 'numerate' workers are those who are conscious of their existing skills, confident in their use, and can see possibilities for further development and transfer of them to other situations. With this in mind, there is another danger of taking an integrated approach to numeracy skills development. It is possible that, when skills are embedded or invisible within larger tasks, there will be not be the desirable increase in learners' awareness of having developed new numeracy skills. Thus neither their numeracy self-image nor their confidence for future development will benefit from the training. Trainers conducting integrated training should therefore ensure that workers are encouraged to identify their numeracy skills and learning and reflect on its usefulness—a similar process to a personal skills audit. Professional development or trainer resources would obviously be needed to facilitate these approaches.

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Support document details

Additional information relating to this research is available in *Thinking beyond numbers: Learning numeracy for the future workplace—Support document*. It can be accessed from NCVER's website <http://www.ncver.edu.au/publications/1795.html>. The document contains:

- Literature review
- Consultation and support
- Interview schedules
- Case studies
- Stakeholder and case study managers' interview analysis notes.

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